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TACTICAL ENGAGEMENT SIMULATION TRAINING: A METHOD FOR LEARNING THE REALITIES OF COMBAT

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ENGAGEMENT SIMULATION TECHNICAL AREA

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Training of combat arms units requires a different approach from conventional instructional system development (ISD) practices. From a systems perspective, unit performance may be more than the sum of individual performances. In battle, subunits interact, and unit and subunit behavior is contingent on the behavior of an intelligent adversary. Conditions that initiate complex combat behavior can rarely be specified in advance.

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Item 20 (Continued)

The idea of "emergent" rather than "established" situations provides a framework for considering situationally determined unit behavior. The empirical approach called engagement simulation involves the detailed observation and recording of "naturally occurring" tactical behavior in what military experts agree is a valid, if incomplete, representation of combat. The simulation procedures provide for data collection and analysis.

From the data collection and analysis, critical combat behaviors should stand out, to be used to describe the full range of tactical behaviors for which training must be provided. The patterns of occurrence of critical combat behaviors may be useful in explaining how or why a particular outcome came about in a given situation.

This identification of critical combat behaviors in the emergent situation represented by combat may be able to provide improved specification of training content (documented in improved Army Training and Evaluation Programs), improved training diagnosis, and improved determination of unit readiness.
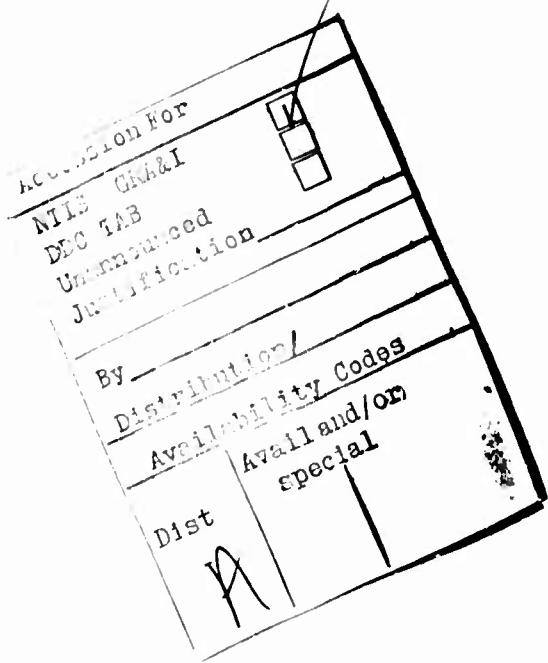
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iii

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In 1971 the Army Research Institute for the Behavioral and Social Sciences (ARI) initiated research which led to the development of a training method now known as tactical engagement simulation training. This method for combat arms units in the infantry, armor, field artillery, and air defense artillery provides an environment for the training of tactical skills for a complete unit. This paper discusses theoretical background and methods for determining what tactical behaviors are related to successful mission accomplishment, thus establishing the necessary content of tactical training. An earlier version was presented at the 1978 annual meeting of the American Educational Research Association to the Military Education and Training Special Interest Group. The research was conducted in response to the requirements of Army Project 2Q763743A773 and the TRADOC Systems Manager for Tactical Engagement Simulation at the U.S. Army Training Support Center, Fort Eustis, Va.
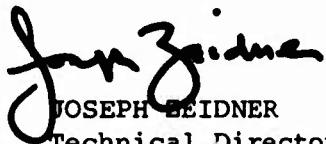
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TACTICAL ENGAGEMENT SIMULATION TRAINING: A METHOD FOR LEARNING
THE REALITIES OF COMBAT

BRIEF

Requirement:

   To develop a training system for preparing soldiers in units for
the complex, fluid situations normal to battle.

Procedure:

   This paper describes the systems perspective and the idea of
emergent situations which led to the training method called engagement
simulation. Engagement simulation for combat units--infantry, com-
bined arms, armor, and air defense artillery--involves the detailed
observation and recording of "naturally occurring" tactical behavior
in what military experts agree is a valid (but admittedly not complete)
representation of combat. Data collection and analysis procedures re-
quired by this approach are described briefly.

Findings:

   Over a series of data collection opportunities, critical combat
behaviors should emerge which may be used to describe the full range
of tactical behaviors for which training must be provided. These
critical combat tasks should not be considered as events that will or
must occur for every exercise to assure successful mission accomplish-
ment. The occurrence or pattern of occurrence of these critical com-
bat behaviors can serve to explain how or why a particular outcome
occurred for a given situation.

Utilization of Findings:

   The identification of critical combat behaviors in the emergent
situation represented by combat may be used to provide (a) improved
specification of the content of training (documented in improved
ARTEPs using engagement simulation as the training vehicle), (b) im-
proved training diagnosis, and (c) improved unit readiness determination.

TACTICAL ENGAGEMENT SIMULATION TRAINING: A METHOD FOR LEARNING
THE REALITIFS OF COMBAT

CONTENTS

LIST OF FIGURES

TACTICAL ENGAGEMENT SIMULATION TRAINING: A METHOD
FOR LEARNING THE REALITIES OF COMBAT

In the last few years there has been a shift in emphasis in Army training from the formal school setting to training in the field, and from individual training to the collective training of crews, teams, and units. This shift has required new approaches to training, new procedures for assessing tactical proficiency, and new ideas on how to determine critical behaviors and behavior patterns required in a dynamic combat environment.

This paper first describes a method of collective training for combat arms units: infantry, armor, field artillery, and air defense artillery. Known as engagement simulation, this method provides an environment for the training of tactical skills for a complete unit. The paper, however, primarily discusses a method for empirically determining which tactical behaviors are related to successful mission performance, under which situations they are appropriate, and the relationships among tactical behaviors. This paper will describe a procedure for using the tactical engagement simulation training environment to determine critical tactical behaviors and thus to provide the basis for establishing the necessary content of tactical training.

THE TRAINING CHALLENGE

Combat is a complex environment that requires confident decisions to be made under extreme pressure. Combat is also a dynamic, constantly changing environment, and the force demonstrating superior flexibility in its actions and reactions has the advantage.

To reach the required high level of combat effectiveness, unit training must follow a certain progression. When assigned to a unit, the individual officer or enlisted man must become fully proficient in his individual duties. He must then learn to work effectively as an integral member of a small team (e.g., rifle fire team, tank crew, battalion staff). Finally, he and the other members of his team must operate as members of a larger coordinated unit (e.g., rifle squad, tank platoon, battalion).

In combat, "the generals concentrate the forces, the colonels direct the battle, and the captains fight.... The guy with the least experience, the toughest job, and the most difficult environment is the captain." (General William DePuy, address to AUSA Convention, October 1975) This quotation reflects an appreciation for the fact that the captain, with the least time in service of the commanders described, has the greatest need for training. The captain's subordinates--first and second lieutenants who have even less time in service--also must learn relevant tactical skills. Among the enlisted ranks

there is the need for effective tactical training which will lead to coordinated functioning of small tactical elements--a rifle squad or a tank crew--as part of a larger organizational entity.

Junior officers and their subordinates who do the fighting are presented with what can only be described as a unique work environment. What does this environment look like? A description of the "difficult environment" mentioned by General DePuy will help the reader appreciate the special demands of ground combat.

Figure 1 shows a small (reinforced platoon level) combined arms team, composed of both infantry and armor elements, involved in a meeting engagement mission with an enemy unit of similar composition. The combined arms team in this example is composed of a tank platoon (20 men and 5 M60A1 tanks), 2 mechanized infantry squads (11 men and 1 armored personnel carrier (APC) per squad), and 2 TOW antitank weapons (mounted on an APC with a crew of 4). This combined arms team is commanded by a lieutenant.

Once given his mission, and before he leaves his assembly area, the lieutenant must plan his scheme of maneuver, based upon a knowledge of his own assets, the best estimate of the enemy's strength and disposition, and known environmental factors (e.g., terrain, weather).

The commander of this team has the responsibility for orchestrating the activities of the 50 men and 9 vehicles under his command against an intelligent, equally motivated threat force. The team commander has a variety of assets to apply to the mission at hand; he must decide how to utilize these assets--both men and equipment--most effectively. Among the decisions the team leader must make for a given situation are how should he deploy his medium-range antitank weapon capability (the main gun on the M60 tank and his TOWs), how should be deploy his infantry personnel and their weapons, and what maneuver routes should his tactical elements follow?

Once the commander has issued his order, each subordinate leader must decide exactly how his element will carry out the commander's order.

At a prescribed time the unit crosses the line of departure (LD) and moves to meet the enemy. The figure shows how the unit is deployed after crossing the LD. Also shown is the disposition of the enemy forces at the same point in time.

Once the enemy is engaged, the team commander and his subordinate leaders must respond effectively and efficiently to the actions of the enemy. The team commander must be continually aware of the interdependent relationships among unit elements. Coordination of the activities of these assets is the paramount task of the team leader and his subordinate leaders.
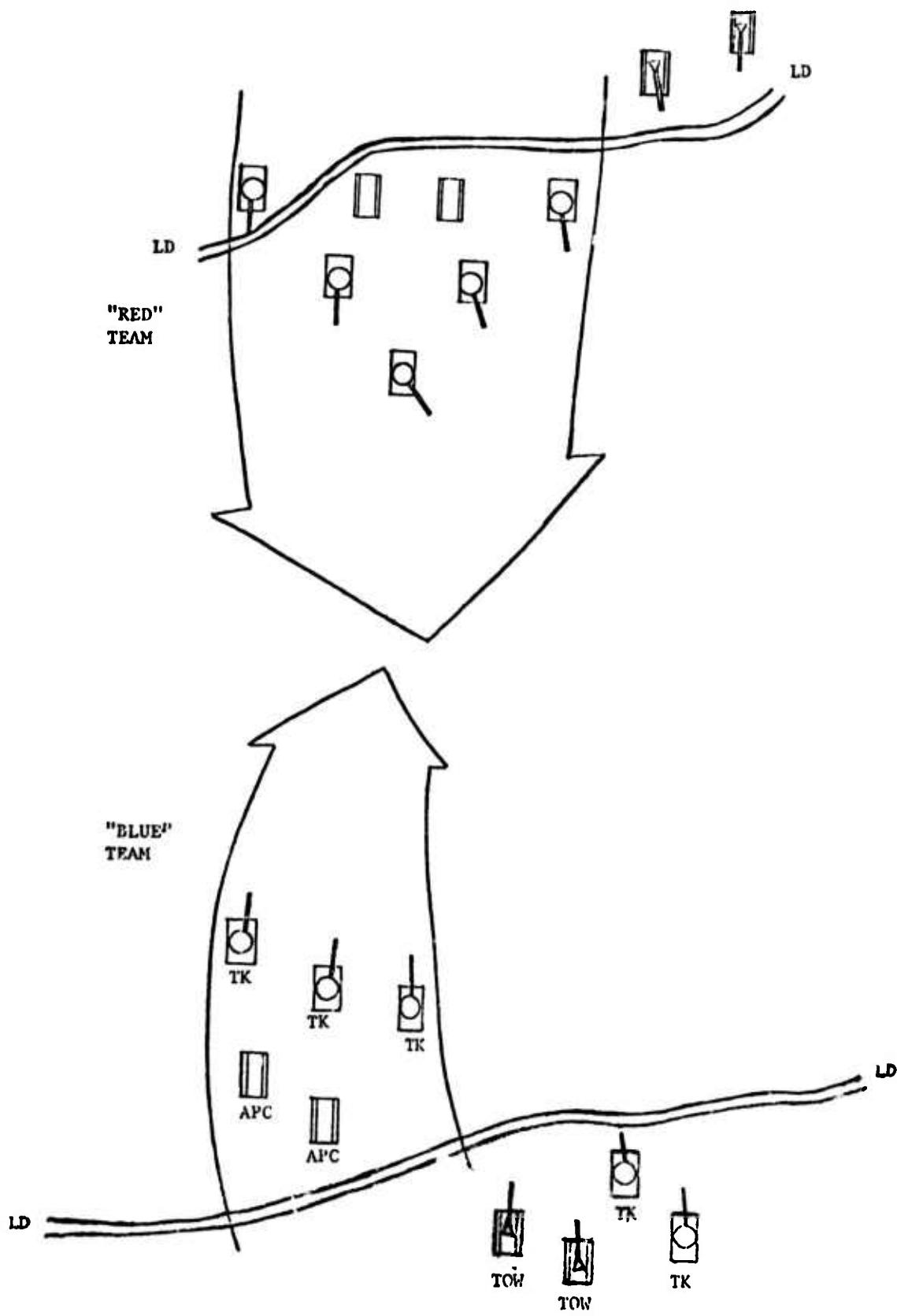
Figure 1. Combined arms meeting engagement.

During an engagement, all unit personnel are potential decision-makers, responding appropriately to enemy actions. Even the individual foot soldier may be a significant factor in the outcome of a battle by proper employment of his LAW (light antitank weapon) or a well-placed hand grenade in the open hatch of an enemy tank!

For the unit to be successful in combat, individuals and unit elements must be able to

- Maximize the effects of available weapons on the enemy,

- Minimize the effects of enemy weapons,

- Achieve effective intra- and inter-unit coordination, and

- Respond adaptively to enemy actions in a dynamic, interactive environment.

For these skills to be learned, leaders and soldiers within the unit must have an opportunity to gain tactical experience. This training experience provides the basis for the decisions made in combat, decisions that are required of each individual facing the enemy regardless of rank or position.

THE TRAINING ENVIRONMENT

In 1971 the Army Research Institute for the Behavioral and Social Sciences (ARI) initiated research which led to development of a tactical training method now known as tactical engagement simulation training. Engagement simulation was designed to elici the same behaviors as did combat. The cues to which unit members respond in training are the same as those to which they respond in battle. They have the opportunity to respond to the situation as they would in combat, with the situation changing realistically as a result of their actions.

To provide the realism required for two-sided, free-play exercises, a credible means of assessing casualties was needed. Engagement simulation became a reality with the development of a casualty assessment technique for the basic infantry weapon, the M16 rifle. This development and the subsequent development of techniques for other infantry and armor weapons represented the breakthrough necessary to simulate the tactical environment.

Infantry exercises are centered around the M16. Each soldier's weapon is equipped with a 6X telescope, and all participants wear 3-inch-high, black, two-digit numbers on their helmets. These numbers can be read with the telescope at distances up to 250 meters. Opponents read each other's numbers using the telescope, an action analogous to aligning the rifle sights on a target. When a man on one side

identifies a number, he fires a blank round and reports the number to a controller.[1] The controller then radios the number to a controller with the opposing force, who assesses the man whose number was identified as a casualty. This can be accomplished in 5 to 10 seconds. In this way both sides can inflict casualties with effective M16 fire in a manner very similar to combat. For each weapon found in an infantry unit, there is a similar casualty assessment technique.

For the M60 tank, the controller's telescope is mounted in the breech of the main gun. When the controller in the tank determines that the main gun is centered on a target at the time of simulated impact, he assesses a casualty. The controller then radios the number of the tank or other vehicle that was hit to the controller on the other side, who removes the vehicle from action.

Artillery fire is realistically simulated by detonating artillery simulators at the actual point requested by an artillery forward observer (FO). When simulated rounds are detonated by artillery throwers, controllers assess casualties within the "kill radius" of the simulated artillery round and take them out of action.

To coordinate these diverse elements and integrate them into an effective combat simulation, control personnel on both sides are in direct communication with each other and with a Net Control Station (NCS). This control network is the lifeline of the exercises. It carries the communications by which controllers maintain the real-time responsiveness of the simulation and informs the NCS of events as they occur. Personnel at the NCS record casualties and significant tactical events.

An important aspect of engagement simulation training occurs immediately after the exercise. The opposing forces who participated in an exercise are brought together to conduct a detailed After Action Review (AAR). During the AAR, casualties are reviewed, based upon the record of casualties and critical events maintained at the Net Control Station. Interaction among exercise participants from both sides during the AAR provides extremely effective feedback to reinforce and extend learning gained from the exercise itself.

Given these casualty assessment techniques and a group of trained controllers, a wide range of infantry and armor missions can be practiced under realistic conditions. By combining infantry, armor, and anti-armor techniques, full combined arms exercises can be staged.

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[1] Controllers are administrative personnel accompanying each tactical element who assess casualties, communicate casualties, and activate weapon simulation devices.

5

Engagement simulation training techniques provide an opportunity for learning tactical skills. Engagement simulation is not a didactic method of instruction. It does not teach; it facilitates learning.

TRAINING OBJECTIVE DEFINITION

Baker (1976) has correctly noted that "all too often, team training exercises are just exercises--not learning experiences. What is learned, if anything, is simply not known." ARI has undertaken a major research effort intended to identify, as precisely as possible, what is learned (i.e., what are the relevant tactical skills), the nature of skill acquisition and retention for critical tactical skills, and the procedures that should be followed for the reliable and valid evaluation of unit tactical proficiency.

The Army has always had to train many different types of units. For many years it made an explicit attempt to identify critical mission tasks and to measure tactical proficiency to determine the state of unit readiness. From World War II to the early 1970s, the Army utilized Army Training Programs (ATP) and Army Training Tests (ATT) for this purpose. These training programs and evaluation tests were developed for newly mobilized units that were "built from scratch," which was the case in World War II. The Army was not concerned with the continuing training and evaluation of established units.

In the early 1970s, performance-oriented training became the accepted approach for Army training, and the Army adopted an instructional system development (ISD) model for training. Under this model, training objectives were concerned with real-world behaviors and were stated in terms of criteria or standards that would define mastery. The heart of this approach was task analysis of the operational environment in which a task would be performed.

The success of this approach in the individual training environment led training developers in the Army's Training and Doctrine Command (TRADOC) to adapt the notion of criterion-referenced individual training to unit training and evaluation. This led to the development of a family of Army Training and Evaluation Programs (ARTEPs), which were intended to delineate the critical missions for each type of Army unit for which an ARTEP was prepared.

Just as task analysis was the heart of the individual training ISD model, task analysis of complex unit functions within a given tactical mission was required for the generation of unit ARTEPs. For each critical mission, it was necessary to specify the tasks required, the conditions under which they are performed, and the standards of performance required. With the ARTEP there was a real attempt to provide for more objective measurement; for each task, the performance standard was intended to provide a criterion against which to evaluate a unit's proficiency.

The ISD model, which was adapted for unit training purposes and relies on task analysis, rests on the following assumptions:

- That through this analytic approach, all critical processes involved in successful mission accomplishment can be identified;

- That performance standards can be established for each critical process; and

- That, if a unit demonstrates its ability to execute each critical process to performance standards, it would have accomplished its tactical mission.

A reason for questioning the first assumption is the complexity of the behaviors required on the battlefield: the effective integration of men, weapons, and procedures dynamically responding to the actions of the enemy. When considering the necessary interactions among unit elements--and also the effects of terrain, force ratio, and weather-- is it really practical to assume that "all critical processes involved in successful mission accomplishment" can be identified by the task analytic process?

The second assumption may be questioned for much the same reason. The use of standards (most usually measured in terms of time and accuracy) is entirely appropriate for individual and crew tasks involving equipment operation. However, in the tactical environment against an intelligent adversary, predetermined universal standards do not appear to make a great deal of sense. The manner and speed with which a task is accomplished--or if it is even required at all--is usually situationally determined. The behavior of the enemy is the main determinant of appropriate unit behavior, but performance is also influenced by such external factors as terrain, relative force strength, and weather.

During initial ARTEP development an attempt was made to establish precise universal objective standards. The futility of this endeavor was soon seen. Currently, ARTEP "standards" are merely statements of subtasks for a given task or are such vague standards, such as "does not sustain excessive casualties." The use of subtasks as standards rests on the assumption that accomplishments of each subtask will lead to successful accomplishment of the task; this may or may not be valid in a combat situation. The second procedure leads to standards which are so vague as to be meaningless.

The third assumption can only be valid if all relevant processes have been identified, if performance standards can be established for each critical process, and if the performance of a prescribed sequence of activities can be considered to be a valid measure of successful mission accomplishment. The nature of combat and the complex inter-relationships among the elements comprising the meeting of a combat unit and an enemy force present a dynamic, ever-changing work environment.

7

In such an environment the appropriate sequence of occurrence of tactical behaviors is usually situationally determined. Even the occurrence of a given behavior is situationally determined.

The preceding paragraphs have tried to indicate some of the problems in trying to apply the task analytic approach to the development of unit training programs. The concern is not with the task analytic approach but with its application in the design of such programs.

A SYSTEMS PERSPECTIVE

The combat unit may be viewed as a man-machine system. In many ways it is like other military man-machine systems composed of men, machines, and procedures. However, when most people think of a military system, they usually think of a complex, computer-based system, such as an early warning/air defense system receiving inputs from an array of radars and providing outputs in terms of orders to interceptor aircraft. Such a system has been described as "machine ascendant," where the man is largely an operator following prescribed procedures. A combat unit, on the other hand, is a "man ascendant" system, in which the man in the system is less an operator and more a decisionmaker. In a machine ascendant system, men follow established procedures with one or, at most, a small number of paths to the required system goal. In the man ascendant system represented by a combat unit, a number of routes are possible to the system goal, which is successful mission accomplishment.

Since the combat unit is a system composed of men, equipment, and procedures which must interact effectively to adjust to the demands of the tactical situations, training of the unit should be structured accordingly. "Most trainers approach team training as though the relationships (among team members) were additive; i.e., they tend to focus on each individual member and train each one up to some prescribed level, then join them together as a team—assuming that a team is really the sum of its parts" (Baker, 1976). In the complex environment represented by ground combat, the interactions required among men at all levels suggest that adherence to an additive model can lead to overlooking important relationships within the human component of the system.

Considering only the human component of the system, however, can also lead to overlooking other important relationships. Boguslaw and Porter (1962), in talking about teams in a complex system, suggest that the word "team" should connote more than the relationships among people and should be used to describe the relationships among men, machines, and work procedures. "Teams are contrived by men to accomplish certain goals. The relationships among men, work procedures, machines, and machine procedures have meaning for the team only to the extent that they contribute to or detract from the effective and reliable attainment of the goals" (p. 388).

8

Viewed from a systems perspective, the military training researcher should be concerned not only with the men to be trained, although this is where his emphasis is placed; but he must also keep in mind the equipment (i.e., weapons systems) to be employed on the battlefield and the work procedures to be followed in their tactical employment.

The combination of men, machines, and procedures into an effective fighting force, going up against a formidable adversary, requires a new way of thinking about how to describe a unit's performance and the performance of each subunit. Boguslaw (1961) and Boguslaw and Porter (1962) describe, for a systems environment, a continuum of situations in which actions can occur. One pole consists of established situations, the other pole of emergent situations. An established situation is defined by these authors as one in which (a) all action-relevant environmental conditions are specifiable and predictable, (b) all action-relevant states of the system are specifiable and predictable, and (c) available research technology or records are adequate to provide statements about the probable consequences of alternative actions. An emergent situation, on the other hand, is defined as one in which (a) all action-relevant environmental conditions have not been specified, (b) the state of the system does not correspond to relied-upon predictions, and (c) analytic solutions are not available, given the current state of analytic technology.

Established situations are probably best typified by the tasks required of equipment operators in a machine ascendant system, where initiating conditions and task outcomes are predictable. In emergent task situations, task behavior cannot be specified exactly, initiating conditions may not always be known, and task behavior must be viewed on the basis of response to an immediate situation.

In their 1962 article, Boguslaw and Porter consider emergent situations in the context of complex, computer-based machine ascendant systems for situations in which a team is nearing or actually experiencing conditions of information overload or "emergency" situations. When the system is experiencing an overload or emergency situation, decisions must be made quickly and under conditions of relative uncertainty. Combat, however, represents a situation of even greater complexity and uncertainty than that considered by Boguslaw and Porter. In the emergent situation represented by combat, leaders and their men respond to a range of situational cues provided by the enemy. They must evaluate behavioral options, make decisions, coordinate plans, and then execute these plans collectively. The appropriateness of the decisions made can then be judged by subsequent outcomes.

The "enemy" has a primary role in initiating action and reaction. Combat units must respond appropriately to the behavior of their adversary; unit leaders must apply available resources effectively to the particular situation confronting them; and unit personnel must execute their leaders' orders efficiently. As a combat engagement unfolds, continual adjustments must be made that reflect the dynamic

9

interplay of the two forces. Unit personnel at all levels must adapt their behavior to the situation of the moment.

SIMULATION OF THE COMBAT SITUATION

To provide an environment for isolating relevant combat skills, it is necessary to resort to simulation. Simulation must provide the opportunity for the full range of combat behaviors to occur in response to typical combat stimuli. In the environment provided by engagement simulation, the following are present:

- Unit members are active participants in the situation, not passive observers.

- The sets of cues to which they respond approximate those encountered in combat.

- The situation changes realistically as a result of participants' actions.

- Feedback that occurs as a consequence of participants' actions is immediate and realistic.

In addition, the simulation of the combat environment provided by engagement simulation permits:

- Collection of a full range of objective performance data,

- Variation of the complexity of the simulated tactical situation, and

- Simulation of the varied conditions of combat across differences in mission, terrain, visibility, etc.

Although all of the above features of engagement simulation are important, the one which may be most easily overlooked is the last, which may be the most important:

> The art of war has no traffic with rules, for the infinitely varied circumstances and conditions of combat never produce exactly the same situation twice. Mission, terrain, weather, dispositions, armament, morale, supply, and comparative strength are variables whose mutations always combine to form a new tactical pattern. Thus, in battle, each situation is unique and must be solved on its own merits. ("Infantry In Battle," The Infantry Journal, 1939).

This quotation shows clearly why it is necessary to think about emergent task situations and why training opportunities in a simulated tactical environment must be sufficient in number to insure that

10

soldiers at all levels are proficient enough to solve each unique combat situation "on its own merits," i.e., adaptively. Engagement simulation provides this opportunity.

THE SEARCH FOR A TAXONOMY OF CRITICAL COMBAT BEHAVIORS
IN EMERGENT SITUATIONS

It is not enough to say that we must go beyond consideration of established situations and look at more complex, situationally determined emergent situations. Nor is it sufficient to add that we have a training environment in which critical combat tasks may be learned. The training researcher must attempt to understand what is happening on the tactical battlefield in order to develop a taxonomy of critical combat tasks and to delineate behavioral objectives related to a given tactical mission goal. We feel that engagement simulation technology provides the opportunity to do this and that the methodology described below will help achieve this end.

When considering the simulation of a complex system, Boguslaw and Porter assert that "because of the interactions of the many variables involved, the problems of measurement are characteristically enormous. Exact replications of experiments become in effect impossible, since many of the specific tasks with which the team must cope are produced by the consequence of earlier actions. Once a large-scale simulation exercise has begun, the experimenters have little control over the events which follow. Often the nature of the research changes from what would generally be recognized as controlled experimental research into what might best be termed naturalistic observation. This, in itself, is not necessarily unsound or unscientific" (1962, p. 414).

Another psychologist who recognizes the complexity of real-world relationships, although in this case not in a systems context, is Lee Cronbach. In his article entitled "Beyond the Two Disciplines of Scientific Psychology" (1975), Cronbach admits that in the continuing study of aptitude-treatment interactions, "interactions are not confined to the first order; the dimensions of the situation and of the person enter into complex interactions" (p. 116). Cronbach explains that the experimental strategy dominant in psychology since 1950 unrealistically restricts the range of situations that can be studied and thereby conceals important higher order interactions. Experimental control and systematic correlations answer the formal question stated in advance; however, Cronbach feels "intensive local observation goes beyond discipline to an open-eyed, open-minded appreciation of the surprises nature deposits in the investigative net" (p. 125). Intensive local observation, in addition to short-run control, will, according to Cronbach, "help to develop explanatory concepts, concepts that will help people use their heads .... short-run empiricism takes soundings as one proceeds into unfamiliar waters" (p. 126).

11

These two authors agree that in order to understand the world around us, we may be better served initially by what could be called "naturalistic observation" of (simulated) real-world events than by controlled experiments looking at a limited number of variables and the interactions among them. They advocate observation of naturally occurring events to isolate those behavioral variables having a relationship to successful attainment of the system goal and to identify the functional relationships among variables. (Controlled experiments may then be used to examine variables of special interest.)

In engagement simulation exercises, events occur naturally as part of the give-and-take between the two adversaries. Simulated engagements continue from initial tactical planning until they reach their logical conclusion. Thus a series of engagement simulation exercises can provide an opportunity for observing and recording tactical behaviors in emergent situations.

Engagement simulation control procedures permit the collection of precise casualty data. At all points during an engagement simulation exercise, military data collectors can record the observable activities of those involved on both sides of the engagement. Relatively precise time and location data for all tactical elements can also be obtained.

ARI's current engagement simulation field research focuses on the following list of behavioral data elements which we feel are necessary to describe battlefield activity.

CRITICAL BEHAVIORAL DATA ELEMENTS:

- WHO (vehicle or tactical element identifier)
- WHEN (exercise time)
- WHERE (map position)
- WHAT
  - PLANNING (prior to the exercise)
  - FIRING
    Direct Fire (M16 rifle, tank main gun)
    Indirect Fire (artillery, mortar)
    Other (hand grenade, mine)
  - COMMUNICATING
    Ordering/Guiding
    Requesting
    Reporting
  - MOVING
  - HALTING
  - SEARCHING
  - DETECTING
  - DISMOUNTING
  - MOUNTING
  - RECEIVING FIRE
    Direct Fire
    Indirect Fire
    Other

12

To record these behavioral data during engagement simulation exercises, six data collection instruments are being used:

- MAP

    - Location and time data annotated on a 1:25,000 scale map

- NET CONTROL SHEET

    - Target
    - Firer
    - Time casualty inflicted

- TACTICAL EVENT ACTIVITY RECORD (for each tactical vehicle or rifle fire team)

- INDIRECT FIRE (ARTILLERY) DATA FORM

- COMMUNICATIONS DATA FORM

    - Sender
    - Receiver
    - Type of message

- LEADER PLANNING RECORD

Also recorded are external conditions having a direct bearing on an exercise--the tactical mission of each side, relative force strengths, terrain, weather, and chance events such as vehicle breakdown.

To provide a capability for recording and analyzing the wealth of objective performance data available from an engagement simulation exercise, ARI, with contractual assistance, has developed an Automated Tactical Operations Measurement System (ATOMS). ATOMS is comprised of data collection instruments, associated data collection and reduction procedures, and a software package for generating a plot of all tactical movements by time and calculating summary descriptive statistics from which further, more detailed, analyses may be made.

The first full-scale tryout of the ATOMS was completed in March 1978, during a 2-week series of combined arms exercises at Fort Carson, Colo. A detailed analysis of the data will (a) identify those tactical performance variables that describe unit performance, (b) identify functional relationships among performance variables, (c) identify and characterize meaningful "phases" of tactical engagements, and (d) analyze the performance of subunits in relation to that of the unit as a whole.

In the attempt to determine the critical behaviors and organizational dynamics of ground combat, the ATOMS data base will be queried to provide summary data on performance variables such as the following:

- Range of enemy detections
- Range of successful target engagements
- Casualties as a function of:
  - Number of shots fired
  - Target type
  - Firer type
  - Exercise time
- Detections leading to casualties
- Detections reported and subsequent actions taken
- Communication patterns (who talks to whom)
- Communications content (by message type)
- Perceived versus actual subunit status
- Perceived versus actual subunit location
- Vehicle positions at given point in time
- Movement patterns of subunits

In all, over 200 questions of this type have been generated by civilian researchers and military personnel familiar with engagement simulation exercises. They have probably been able to anticipate the most critical variables with some accuracy, having observed many instances of good and poor tactical behavior. This experience base will serve as initial entry points into the wealth of objective performance data included in the ATOMS data base. These data will, in turn, help to provide answers to more global questions such as:

- What method for employing long-range antitank weapons is most closely related to mission success?

- Under what tactical conditions are infantry resources (rifle and machine gun teams) most effectively employed?

- What defense posture is most related to success in a defensive mission?

- What is the relationship of mission success to a leader's knowledge of the status and location of assets under his control?

- What is the relationship between tactical plans and their effective execution?

It will also be possible to display graphically for each exercise the position and status of all tactical elements on both sides at any given point in time. A sequence of such "snapshots" may be used to help interpret the tactical dynamics as they unfolded during an exercise. A leader's deployment of his subunits relative to the position of the opposition at a given time may be evaluated against a subsequent "snapshot" displaying the consequences of his actions.

14

As the ATOMS data base grows—with engagement simulation exercise data collected during different field tests, for different tactical missions, at different locations, and under different environmental and terrain conditions—the specificity or universality of appropriate tactical behaviors or behavioral patterns can be determined. In this manner it should be possible to derive a taxonomy of critical combat tasks for emergent tactical situations.

With these data in hand, it should also be possible to separate system effects directly related to the tactical proficiency of the human component, as well as the external factors which can exert a major influence on total system performance: tactical mission, relative strength of opposing forces (force ratio), terrain, weather, and "chance events."

SUMMARY

We have argued that the training of combat arms units requires a break from certain conventional ISD practices. A systems perspective that considers the complex interactions of men, machines, and procedures leads one to question the notion that unit performance is the sum of the individual performances of the unit members. Combat is too complex to be described by an "additive" model. Interactions among subunits, each with its own mission, must be considered. And of primary importance is the fact that unit and subunit behavior is contingent upon the behavior of an intelligent adversary in the give-and-take of battle. Initiating conditions for complex combat behavior can rarely be specified exactly in advance. In addition, "the infinitely varied circumstances and conditions of combat never produce exactly the same situation twice."

The notion of "emergent situations"—as contrasted with "established" situations—helps to provide a basic framework for looking at unit behavior which must be considered situationally determined. We argued that conventional task analytic techniques are not sufficient to describe the complexities of combat. We proposed an alternative. This empirical approach involves the detailed observation and recording of "naturally occurring" tactical behavior in what military experts agree is a valid (but admittedly incomplete) representation of combat. We briefly described the data collection and analysis procedures required by this approach.

Over a series of data collection opportunities, critical combat behaviors should emerge which may be used to describe the full range of tactical behaviors for which training must be provided. In whatever way these critical combat tasks are documented (e.g., in an engagement simulation-based ARTEP), they should not be considered as events that will or must occur for every exercise to assure successful mission accomplishment. In the emergent situation represented by combat, their occurrence is situation-dependent. The occurrence or pattern of

15

occurrence of these critical combat behaviors can serve to explain how or why a particular outcome occurred for a given situation.

It is too early to tell how successful this empirical approach to the specification of critical combat behaviors or tasks will be. However, it should provide a more penetrating insight into the dynamics of combat and lead to a more comprehensive delineation of critical combat tasks.

If this approach is successful, the identification of critical combat behaviors in the emergent situation represented by combat may be used to provide improved specification of the content of training (as documented in improved ARTEPs, using engagement simulation as the training vehicle); improved training diagnosis; and improved unit readiness determination.

This paper does not attempt to carry this approach further into a discussion of how improved combat unit training programs can be developed nor does it discuss procedures for training diagnosis and unit evaluation. We have attempted only to propose the concept of "emergent" situations viewed from a systems perspective as a more appropr ate way of thinking about complex tactical behavior, and to descr an empirical procedure which may be useful for developing a more comprehensive taxonomy of critical combat tasks than do current analytic procedures.

REFERENCES

Baker, J. D. The training effectiveness of simulation. In Volume IV, Proceedings of the First International Learning Technology Congress and Exposition on Applied Learning Technology. 21-23 July, 1976, Washington, D.C.

Boguslaw, R. Situation analysis and the problem of action. Social Problems, 1961, 3, 212-219.

Boguslaw, R., & Porter, E. H. Team functions and training. In Gagne, R. M. (Ed.), Psychological principles in system development. N.Y.: Holt, Rinehart and Winston, 1962.

Cronbach, L. J. Beyond the two disciplines of scientific psychology. American Psychologist, February 1975, 116-127.

DePuy, W. Address to Associates of the United States Army, Washington, D.C., October 1975.

"Infantry in Battle." The Infantry Journal, 1939.

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19